# Appendix G
# Benchmark Studies

DEPARMENT OF THE ARMY
U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE (PROVISIONAL)
ABERDEEN PROVING GROUND, MARYLAND 21010-5422

REPLY TO ATTENTION OF MCHB-DL-EE

# EXECUTIVE SUMMARY

## STUDY NO. 75-23-YS50-94
## FINAL REPORT
## HEALTH RISK ASSESSMENT OF CONSUMING DEER PROM ABERDEEN PROVING GROUND, MD
## MAY 1995

Aberdeen Proving Ground (APG) is a United States Army installation located on the western banks of the upper Chesapeake Bay, Maryland. The APG has been in operation for over 75 years with a primary mission of research, development, and testing of munitions and military vehicles. As a results of APG being on the National Priorities List, an installation-wide he&h risk assessment is currently underway. As part of this h&h risk assessment, all potential human exposure pathways are being investigated to include the food chain. Hunters harvest approximately 800 whitetail deer from AJG annually. To assure public safety, a study was completed by the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) to identify any potential human health hazards associated with consumption of deer harvest&d from APG.

During the 1993 hunting season, scientists from USACHPPM collected 150 deer samples (muscle and liver) from hunters. These samples were analyzed for several explosives and breakdown products, polychlorinated biphenyls (PCBs), heavy metals, and organochlorine pesticides (DDT, DDD, DDE). For background and comparison purposes, deer were also sampled from areas off the installation within in the state of Maryland. Data from the chemical analyses revealed no detectable levels of explosives, PCBs, or organochlorine pesticides. However, low concentrations of several heavy metals were identified in deer from both APG and off post. These values were compressed statistically, but no consistent patterns or trends between the sites and metal tissue levels were seen.

To determine ifthese metal levels posed a hazard to consumers, a health risk assessment was completed. Actual consumption data obtained from a hunter's questionnaire was used to define exposure (eg. how much venison harvested from APG do the hunters and their families actually consume per year). Arsenic, cadmium, chromium, and mercury levels were evaluated using the U.S. Environmental Protection Agency (EPA) Guidance for Risk Assessment at Superfund Sites. Arsenic levels were also compared to established standards - Applicable or Relevant and Appropriate Requirements (ARARs). At the moment, there are no standard EPA methods to evaluate lead and no ARARs for comparison. So lead levels were evaluated using a similar method used by the U.S. Food and Drug Administration (FDA) for lead in shellfish. A synopsis of the findings and associated uncertainties is presented below.

Following the standard EPA risk assessment methodology, cadmium, chromium, and mercury levels in APG deer posed no significant risk to consumers but initially, arsenic levels appeared to contribute the most to the potential risk. However, this risk may be overestimated because ofthe conservative assumptions and uncertainties associated with the toxicity values for arsenic. Also, most reported toxicity values are derived for the inorganic form of arsenic as opposed to the less toxic organic form; but the actual forms of arsenic in deer is unknown at this time. It has been reported in the literature that only 10% of the arsenic found in shellfish is in the inorganic form.

Due to the inherent uncertainties associated with arsenic, levels were also compared to establish standards or Applicable or Relevant and Appropriate Requirements (ARARs). Arsenic levels in deer were compared ***to FDA*** arsenic standards for tolerable residues exposures in beef and pork (0.5 mg/kg and 0.7 mg/kg respectively) associated with arsenic used as a feed additive and the use of arsenical pesticides. Again, most of these values have been established for the inorganic form of arsenic. Levels in deer from APG and offpost sites were similar or slightly higher than these values. Additionally, calculated intake levels of arsenic by hunters eating deer from APG, were compared to acceptable daily intake values for arsenic established by the World Health Organization (WHO). None of the arsenic intake values based on the 95% Upper Confidence Limits exceeded any of the WHO criteria.

Currently, there are no standard EPA methods available to evaluate lead in edible tissue. Therefore, the FDA method for evaluating lead in shellfish was applied in this study. Maximum lead levels of concern were based on exposure factors (EPA standards and hunter consumption data collected during the study) and on provisional tolerable total intake levels for general and sensitive populations (ie. adults, pregnant women, school age children, and children under 6 years). Lead levels in deer tissue were compared to these acceptable maximum levels. Overall the lead levels in deer from both APG and offpost were within the acceptable safe Emits.

Based on these data and considering the conservatism and uncertainty related to the current risk assessment process, the health risk associated with consuming meat from APG deer is no greater than that associated with consuming meat from offpost deer. Therefore, consumption of ARG deer following the current practices identified in this report should not present an elevated human health hazard.

DEPARTMENT OF THE ARMY
U. S. ARMY ENVIRONMENTAL HYGIENE AGENCY
ABERDEEN PROVING GROUND, MARYLAND 21010-6522

REPLY TO
ATTENTION OF

HSHB-MO-T

# EXECUTIVE SUMMARY
# HEALTH RISK ASSESSMENT FOR CONSUMPTION OF DEER MUSCLE AND LIVER FROM JOLIET ARMY AMMUNITION PLANT

Joliet Amy Ammunition Plant (JAAP) is a Government-owned installation currently maintained in a nonproducing, caretaker status by a modified caretaker contractor (Alliant Tech Systems, Inc.). The primary activities included munition production, assembly, storage, and demilitarization. As a result of contamination from past manufacturing activities and pesticide use, a study was initiated to investigate the potential contamination of deer harvested from JAAP.

During the 1992 hunting season, samples of deer liver and muscle were obtained from hunters and analyzed for explosives, PCBs, metals, and organochlorine pesticides. Deer from an offpost site were sampled as a control. Data from chemical analyses revealed no detectable levels of explosives, PCBs, or organochlorine pesticides. Some tissue concentrations of metals were identified in muscle, liver, kidney, and bone.

A human health risk assessment following the U.S. Environmental Protection Agency's Risk Assessment Guideline showed that there were no significant risks associated with consuming deer meat from JAAP due to explosives accumulation. Detectable levels of arsenic, cadmium, chromium, mercury, and lead were found. Arsenic posed a potential health risk; however, the arsenic in offpost reference deer were higher than the JAAP deer. In all instances, the arsenic levels meet acceptable residue levels established by the US Food and Drug Adminstration for food.

## BADGER ECOLOGICAL RISK ASSESSMENT

Background: A tier 1 screening level ecological assessment was performed at Badger Army Ammunition Plant, using simplified assumptions regarding chemical concentrations in prey organisms, to determine the need for further action at the site.

Methods: Abiotic sampling and simple modeling (hazard index) were performed for heavy metal contaminants found in site soils. No biota sampling was performed during this first portion of the study. Chemical concentrations in invertebrate prey organisms were assumed to be identical to measured soil concentrations (i.e., 100% bioavailability was assumed).

Results: Based on the results of the modeling, the potential for adverse risk was identified for three organisms (garter snake, meadowlark and vole) due to heavy metal contamination.

Conclusions: The unacceptably high hazard indices identified for three organisms, based on presumed uptake of heavy metal contaminants, was used as a basis for recommending further investigation at the site. Because of the highly conservative, unrealistic assumptions used in this screening evaluation, the hazard index values may not be indicative of actual site hazard. In order to confirm or refute the findings of the tier 1 study, it has been proposed that potential prey organisms (ants, ground-dwelling insects, flying insects and earthworms) be collected and analyzed for contaminants. If contaminants are found in the prey organisms, the model will be modified using measured concentrations (instead of assuming soil concentrations are equivalent to prey tissue concentrations).

Applications: This study serves as an example of how to perform a simplified, tier 1 screening level ecological evaluation, and how to use the results of the evaluation to design a tier 2 study that will identify the presence or absence of potential hazard to selected ecological receptor populations.

## ABERDEEN PROVING GROUND
## SNAPPING TURTLE (Chelydra serpentina)
## CONTAMINATION SURVEY WORKPLAN

**and**

## ABERDEEN PROVING GROUND
## SNAPPING TURTLE CONTAMINATION SURVEY

Background: Aberdeen Proving Ground (APG), located in northeastern Maryland on the Chesapeake Bay, was established in 1917 as the Ordnance Proving Ground and was established as a munitions post in 1919. The primary mission of APG has been the development and testing of munitions, including chemical warfare agents. As a result, large areas have been impacted by chemical contaminants. Aberdeen Proving Grounds is considered a former hazardous waste site and is listed on the National Priorities List.

Many of the chemicals of concern identified at APG are known to bioconcentrate in aquatic systems and have been found in bodies of water on or adjacent to the site. Chemicals of Ecological Concern

(COECs) found or suspected to occur onsite included PCBs, organochlorine pesticides, metals, explosives and trichlorophenylurea (TCPU). At the present time snapping turtles found in these bodies of water are harvested by local fishermen for human consumption. Because these turtles are the top predators in the local aquatic ecosystem, and because many of these compounds are known to bioconcentrate, the concern existed that ingestion of turtles could constitute a potential threat to human health. Given these concerns and the fact that bioconcentration is difficult to reproduce in the laboratory, a tier 2 study was conducted whereby turtles were collected and the tissues analyzed for COECs. The analytical results were then evaluated quantitatively in a human health risk assessment.

Methods: Tissue sampling of snapping turtles was conducted to determine whether chemicals of concern identified in the existing Baseline Ecological Risk Assessment were bioconcentiating to a significant extent. Four sampling locations were selected to evaluate contaminant uptake (three contaminated areas and one reference area), based on contamination potential and snapping turtle trapper use. The potentially contaminated areas included 1) Carroll Island, used as a chemical agent test site, 2) Watson Creek, located adjacent to a hazardous waste and ordnance disposal area, and 3) Canal Creek, which receives water from lab waste disposal sites, mustard disposal pits, and various production facilities. The reference area was located approximately 5 miles upstream from APG at the Van Bibber drinking water treatment facility, an area thought to be free of site-related contaminants and unlikely to contain turtles impacted by the downstream areas.

An analysis of turtle populations and annual harvest of turtles from each of the areas was conducted to identify an optimum sample size for the study. It was estimated that 25% of the annual harvest (approximately 10 turtles per area) would provide optimum data; however, after evaluation of study areas and turtle populations, it was determined that 15% of the annual harvest (6 turtles per area) was the highest attainable number of turtles that could be collected without severely depleting the Van Bibber population. Six turtles were collected from the 3 sampling areas, and 5 were collected from the reference area. Animals were weighed, sacrificed, and tissue collected for analysis. Muscle tissue (e.g., edible tissue) was analyzed for metals, PCBs, pesticides, TCPU and explosives (see Table G-l for a list of specific analytes).

Results: No military chemicals (TCPU or explosives) were found in any turtles. Low levels of pesticides and PCBs were found in several turtles from two of the contaminated areas, but not the third area. Iron and zinc were found in turtles from all areas (including the reference area). Other metals, including mercury, silver, copper, magnesium, aluminum, chromium and nickel, were found in one or more turtles from the contaminated areas. A quantitative risk assessment of potential ingestion of turtle meat by human receptors indicates that the concentrations of contaminants in turtle tissue do not pose an unacceptable risk to human health.

Conclusions: Because snapping turtles are the top predators in the aquatic ecosystem at APG, and because they are known to bioaccumulate a number of chemicals of concern, this evaluation provided a worst-case look into bioaccumulation of APG-related contamination. Explosives and ureas associated with did not accumulate in tissue. Metals, pesticides and PCBs were found in turtle tissue below any levels of concern for human health. Based on these results, current turtle harvesting practices at APG do not need to be altered to protect human health.

Applications: Although the primary concern for this study was protection of human health, the methodologies used to identify chemicals of concern, analytical sample sizes, areas of concern and top predators can be applied to other aquatic systems where bioaccumulation is of potential concern. This study is particularly relevant in situations where military chemicals may have entered aquatic systems via runoff, groundwater seeps, or direct discharge.

**TABLE G-l**
**ANALYTE LIST - ABERDEEN PROVING GROUND**

Metals:
- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Boron
- Cadmium
- Chromium
- Copper
- Iron
- Lead
- Manganese
- Mercury
- Nickel
- Selenium
- Silver
- Thallium
- Zinc

Pesticides:
- Dieldrin
- DDT (total)
- PCB (total)
- Hexachlorobenzene
- Chlordane

Explosives:
- Trinitrotoluene (TNT)
- 2,4-Dinitrotoluene @NT)
- 2,6-Dinitrotoluene @NT)
- RDX
- 1,3,5-Trinitrobenzene (TNB)
- 1,3-Dinitrobenzene (DNB)
- Tetryl

Ureas:
- Trichlorophenylurea (TCPU)

**RESIDUE ANALYSIS AND HUMAN HEALTH RISK ASSESSMENT OF DEER FROM JAAP ARMY AMMUNITION PLANT**

Background: Joliette Army Ammunition Plant (JAAP) is a government-owned installation that was extensively used from World War II to 1977 for munitions production, assembly, storage and demilitarization. The site is currently maintained in a nonproducing, caretaker status. Deer hunting is currently allowed onsite; however, questions have been raised concerning the safety of eating deer from military installations. Because of these potential human health concerns, a study was undertaken to evaluate the potential for bioaccumulation of site-related contaminants in deer tissues. Results of the bioaccumulation study were then used to evaluate potential human health risks associated with ingestion of deer tissue. Although similar studies have been conducted in the past (Alabama Army Ammunition Plant and Badger Army Ammunition Plant), the analytical detection limits in these previous studies were not sufficiently low to allow an accurate estimation of the levels of explosives that had bioaccumulated.

Methods: Tier 1 studies (abiotic sampling) had previously demonstrated that soils, sediment, surface water and groundwater were contaminated by a number of munitions-related chemicals. Chemicals of potential concern that were identified in the remedial investigation included a number of metals, explosives, PCBs and organochlorine pesticides. Muscle and liver tissues were collected from deer harvested at the JAAP during the deer hunting season and were analyzed for compounds identified during the remedial investigation with known bioaccumulative and/or toxic properties (Table G-2). Tissues were analyzed for PCBs, organochlorine pesticides, mercury, lead, arsenic, chromium, and cadmium. In addition, explosives analysis was conducted because of the limited information in the literature concerning potential biouptake and bioaccumulation of these compounds. Animals were harvested from four areas:

- Load, Assemble and Pack Area (20 animals).
- Manufacture Area (20 animals).
- Background (8 animals).
- Off-Post Natural Area (12 animals).

The sample size of 20 animals was deemed adequate to detect a change of one standard deviation from background with a power of 80%. Residue data were analyzed statistically using a multiway ANOVA.

A human health risk assessment was performed on chemicals detected in deer tissue (both liver and muscle) using standard USEPA methodology. Exposure factors used in the human health evaluation were modified using data from a hunter's survey.

Results: No PCBs, organochlorine pesticides or explosives were found in any tissue samples, but metal residues were found in both liver and muscle tissue. All metals except arsenic were found at comparable concentrations in deer tissue from onsite and background and offpost areas. Arsenic was found at the statistically highest concentrations in deer from the offpost nature area. A quantitative evaluation of human risk associated with ingestion of deer tissue indicated that unacceptably high risks could occur if deer tissue from either the offpost area or the manufacture area were ingested on a regular basis (potential cancer risks as high as 3.5 E-4, hazard index 1.1). The primary contributor to site risk was arsenic.

Conclusions: Although potentially unacceptable human health risks were identified for individuals eating arsenic-contaminated deer from the site, it is likely that arsenic in these tissues was due to naturally occurring background arsenic rather than site contamination. Other site contaminants, including PCBs, pesticides, explosives and metals (other than arsenic) were not found to bioaccumulate in deer tissue at concentrations that could threaten human health.

Applications: Although the primary concern for this study was protection of human health, the methodologies used to evaluate potential bioaccumulation, analytical sample sizes, areas of concern, tissues to be analyzed, and comparison to background should be relevant to other sites. This study is particularly relevant in situations where chemicals (metals, PCBs, pesticides, explosives) may enter

the human food chain through ingestion of deer (or other site herbivores, including domestic animals).

**TABLE G-2**
**ANALYTE LIST AND REPORTING LIMITS (MC/KG)**
**JOLIETTE ARMY AMMUNITION PLANT (JAAP)**

Metals:
- Arsenic (0.025)
- Cadmium (0.025)
- Chromium (0.025)
- Lead (0.025)
- Mercury (0.020)

Aroclors:
- 1242 (0.40)
- 1016 (0.40)
- 1248 (0.40)
- 1254 (0.70)
- 1260 (0.70)

Pesticides:
- o,p'-DDD (0.01)
- p,p'-DDD (0.0 1)
- o,p'-DDE (0.01)
- p,p'-DDE (0.01)
- o,p'-DDT (0.015)
- p,p'-DDT (0.10)

Explosives:
- 2,4,6-Trinitrotoluene (0.10)
- 2,4-Dinitrotoluene (0.05)
- 2,6-Dinitrotoluene (0.10)
- 2-Amino-4,6-Dinitrotoluene (0.20)
- 4-Amino-2,6-Dinitrotoluene (0.20)
- RDX (0.10)
- HMX (5.0)
- 1,3,5-Trinitrobenzene (0.05)
- 1,3-Dinitrobenzene (0.05)

**PLANT UPTAKE OF RDX AND TNT UTILIZING SITE-SPECIFIC CRITERIA FOR THE CORNHUSKER ARMY AMMUNITION PLANT (CAAP), NEBRASKA**

Background: At CAAP an underground plume of groundwater contaminated with low levels of RDX and TNT has been identified, located, and is being tracked. This plume occurs onpost, but extends offpost as well. Concern has been raised by the regulating agencies (USEPA and the State of Nebraska) that even low levels of RDX and TNT in groundwater may become substantially bioconcentrated in irrigated crops and home gardens. Previous investigations of RDX and TNT uptake by plants have not addressed uptake of these compounds from irrigation waters (previous studies focused on uptake from highly contaminated soils). The purpose of this study, which is currently ongoing, is to evaluate potential uptake and bioconcentration of RDX and TNT into edible plants, using irrigation water containing these compounds at concentrations similar to that found in groundwater.

Methods: Common food crop plants will be grown in CAAP soil under controlled, greenhouse conditions, using RDX/TNT contaminated irrigation water. Control plants will be grown under similar conditions, using uncontaminated irrigation water. Crop plants chosen for the study include common field crop species (alfalfa, soybean and corn) and garden crop species (root species - radish; seed

species - green bean; leaf species - lettuce; fruit species - tomato). Shoots and seeds of field crops and edible portions of garden crops will be evaluated for the amount of contaminants present, and growing plants will be evaluated for the presence of adverse symptoms. Chemical concentrations in plant tissues will be compared to the amount of extractable RDX and TNT in soil and the amount of RDX and TNT provided from irrigation water.

Results: Not applicable - study currently ongoing.

Conclusions: Not applicable - study currently ongoing.

Applications: Because most plant uptake studies for explosives are based on models that use highly conservative assumptions regarding biouptake/accumulation, the results of this study should provide a more realistic estimate of the degree of uptake of explosives into plant tissues. This can be useful for both human health and ecological food chain studies. Additionally, this information can be used when calculating site remediation goals that are protective of human health and the environment

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